SYMPOSIUM: PRE-CLINICAL RESEARCH: IMAGING AND DELIVERY CHALLENGES

SP-0514
Small animal irradiators
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In radiotherapy often new ideas are implemented in clinical practice without preclinical research on animal models. On the other hand, in radiobiology often animal models are employed but commonly irradiations are imprecise, using setups that bear little resemblance to clinical state-of-the-art. Recently a new field of research in radiotherapy was born; image-guided precision radiotherapy. Many now believe that by performing precise irradiation of small structures in animal models much may be learned in terms of radiation response of normal and cancerous tissues. New knowledge may be gained on the efficacy of complex spatial and temporal radiation patterns, the synergy of radiation with drugs (not restricted to chemotherapy), the influence of organ motion, and much more. It is hoped that this knowledge could then be translated to cancer patients.
Precision irradiation of small structures in animals such as mice and rats requires special measures to safeguard correct radiation delivery. The new field of research poses many stringent technological demands. The radiation beams are very small, down to sub-millimeter dimensions, with sub-millimeter placement precision. To prevent excessive buildup and penumbra effects, energy of the beams is in the kilovolt rather than megavolt region. This downscaling in energy and beam size poses high demands on the hardware control systems and treatment planning software. To ensure correct beam delivery, high-resolution image-guidance of the irradiation procedure, from the planning stage to the delivery stage, is paramount.
Recently, several image-guided precision irradiation research platforms for small animals became available. Commissioning and operation of this new technology requires special procedures to enable precise and accurate treatments. Examples include highly accurate mechanical alignment of radiation beams, compensation for beam sagging, the use of high-resolution film dosimetry and dedicated phantoms. Attention has also been devoted to establishing optimal workflows for high-throughput studies. Since radiation treatment planning systems for cancer patients are not suitable for the small beams, small animal voxel sizes and low photon energies of the employed beams, dedicated dose calculation software has been developed.
In this presentation the novel image-guided precision irradiation technology will be discussed. Its potential to elucidate radiation interaction mechanisms in biological targets and to advance radiotherapy practice will also be discussed with some examples.

SP-0515
Multi-modal preclinical imaging: challenges and opportunities in cancer discovery and treatment
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Multi-modal imaging is an emerging field in both clinical diagnostics and basic research as it allows monitoring of functional processes and additionally delivers anatomical information. Over the past decade, we have observed an increasing demand for such imaging techniques for different biological and medical applications. Similar to human imaging, small-animal imaging modalities were proposed to combine nuclear medicine techniques such as positron emission tomography (PET) and single photon emission computed tomography (SPECT) with computed tomography (CT) or magnetic resonance imaging (MRI). Although the most clinically applied multi-modality system is PET/CT, in preclinical research this combination suffers from some limitations which are mainly related to the applied radiation dose and the limited soft tissue contrast as well as the sequential scans rather than simultaneous scans, which could provide information for motion correction. In contrast to PET/CT an integrated PET/MRI scanner could provide simultaneous data acquisition for temporal and spatial image fusion. This talk will review several options for multi-modal imaging and results from small-animal studies will be presented.

SP-0516
Optical imaging in pre-clinical research
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Abstract not received

SYMPOSIUM: DOSE MAPPING/ACCUMULATION IN TREATMENT ADAPTATION AND EVALUATION

SP-0517
Dynamic radiation therapy: Errors that impact on deformable dose accumulation (DDA)
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Dynamic radiation Therapy employs deformable image registration (DIR) as a method for automatic contour propagation of regions of interest (ROI) and deformable dose accumulation (DDA). The goal of DDA is firstly to determine if the treatment is being delivered as planned, by acquiring additional image sets through out the course of treatment (in addition to the planning image) and secondly, to adjust the treatment plan if objectives are not being met as intended. In this lecture we describe errors that potentially impact on DDA and a method that can be used to minimize their impact on the resulting accumulated dose distribution. Even though, DIR and DDA do hold great clinical promise for improved prediction of expected normal tissue toxicities and have the potential to allow one to escalate the dose to target structures at constant expected normal tissue toxicity probability (NTCP), i.e. allowing one to pursue an iso-NTCP escalation strategies. Their potential clinical use, however, should be explored carefully in prospective clinical trials.

SP-0518
Practical aspects of the validation for dose mapping/accumulation
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In order to accumulate dose between two treatments or treatment fractions, the underlying anatomy of the patient should be aligned. Due to the changes in the anatomy, such as deformations and motion, non-rigid registration is required. Therefore, dose mapping/ accumulation is directly influenced by the uncertainties of the non-rigid registration method that is used. Uncertainties related to the non-rigid registration include, among others, the consistency or transitivity, low contrast on the input images for intensity-based registrations, and distance to features for feature-based registration. When registrations are inconsistent or non-transitive, the resulting cumulative dose depends on the pathways used to map the dose (Bender et al. Med. Phys, 39(1) 2012, Bondar et al. Med. Phys, 37(7) 2010). Also a large uncertainty in the cumulated dose is generated when images with few visible features are used for the registration, since the registration may not map correctly the homogeneous areas (Zhong et al. Med. Phys, 37(3) 2010, Salguero et al. Med. Phys, 38(1) 2011). It also has been shown that the registration error is related to the distance to the features used in the registration; the further away, the least reliable is the transformation (Zhong et al. Med. Phys, 37(3) 2010, Chi et al. Med Phys, 33(2) 2006). Besides uncertainties related to the non-rigid registration, dose mapping/accumulation also depends on the properties of the dose distribution. For example, large variations were found for an organ at risk close to the target volume after a perturbation analysis for dose addition between external-beam radiotherapy and brachytherapy for head and neck cases (Vásquez Osorio et al. IJROBP, 80(4) 2011). The reason for the large variations was the extremely steep gradient produced by a brachytherapy catheter which was partially included in the organ (constrictor muscle), therefore a small perturbation on the mapped location resulted in a very large variation on the mapped dose. In conclusion, although dose accumulation may give us a better approximation of the dose that was 'really' received by the patient, making decisions only based on the total dose should be done with care, especially when it influences patient treatment. The need for more tools for estimating the degree of certainty of the cumulated dose should be developed and integrated into the clinical process.